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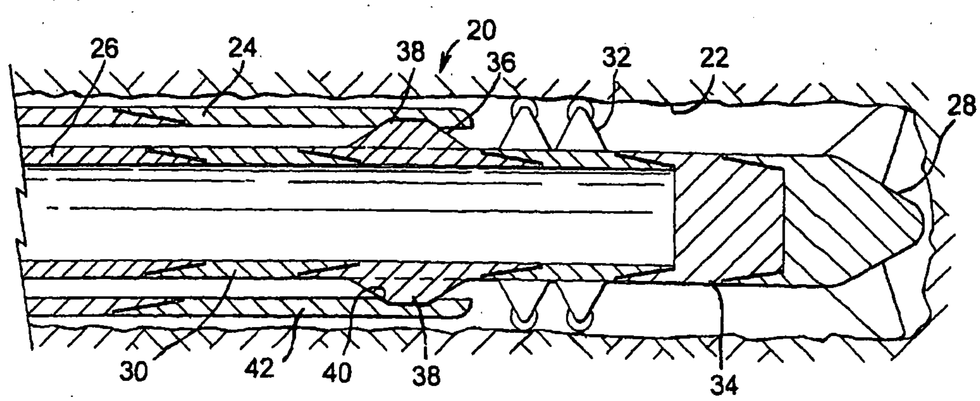

(57) Abstract: A method of drilling and lining a bore in an earth formation comprises providing a tubular outer elongate member and an inner elongate member located within the outer member. At least one of the members is spoolable. A drill bit is mounted to one of the members and a bore is drilled by advancing the drill bit through the earth formation and advancing the members through the bore.

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DRILLING METHOD

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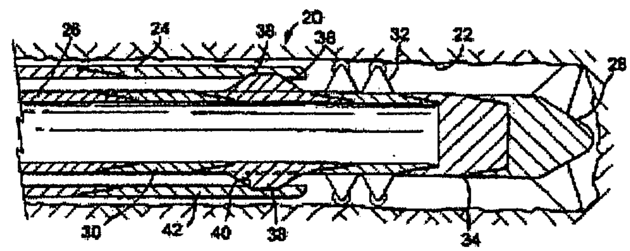
Abstract of **WO0210549**

A method of drilling and lining a bore in an earth formation comprises providing a tubular outer elongate member and an inner elongate member located within the outer member. At least one of the members is spoolable. A drill bit is mounted to one of the members and a bore is drilled by advancing the drill bit through the earth formation and advancing the members through the bore.



DRILLING METHOD

Description of **WO0210549**

DRILLING METHOD
This invention relates to a drilling method, and also to drilling apparatus.

When drilling a bore to, for example, access a subsurface hydrocarbon-bearing formation, it is conventional to: drill a bore using a bit mounted on the end of an elongate support; retrieve the bit and its support; run casing into the bore; and then cement the casing in the bore. Clearly such an operation is time consuming and expensive, and restricts the range of hydrocarbon reservoirs which it is commercially viable to access.

It is among the objectives of embodiments of the present invention to provide a drilling method which is relatively straightforward to execute and which will allow commercial exploitation of, for example, smaller or less accessible hydrocarbon reservoirs.

According to the present invention there is provided a method of drilling and lining a bore in an earth formation, the method comprising the steps: providing a tubular outer elongate member and an inner elongate member located within the outer member; mounting a drill bit to one of the members; and drilling a bore by advancing the drill bit through the earth formation and advancing the members through the bore.

The present invention also relates to the apparatus used in implementing the method.

Thus, it is possible to create a lined drilled bore without the need to run in and retrieve a drill support and then run in a bore liner; the bore is immediately lined by the tubular outer element. Also, the constant presence of the outer member assists in avoiding and addressing difficulties which occur when the bore intersects a problem formation.

Preferably, at least one of the inner and outer members is a support member capable of transmitting force.

Preferably, at least one, and most preferably both, of the members are spoolable.

The use of spoolable supports simplifies the surface apparatus necessary to support the drilling operation, and allows the drilling operation, and retrieving the inner support, if desired, to be carried out relatively quickly and inexpensively: in many cases, it may be possible to carry out the drilling and lining operation without requiring provision of a drilling derrick and associated apparatus; the supports may be run in and retrieved using an injector head and lubricator, or any other suitable method of pressure containment, so that they may be conveyed with the well in production. In other embodiments of the invention, the members may be sectional or jointed, for example one of the members may be formed of jointed pipe, may be expandable, or may be formed of a composite material such as a fibre glass or carbon fibre material.

Preferably, the inner elongate member is tubular.

Thus, the inner support may, for example, be used as a conduit for carrying drilling fluid from surface. Further, the inner support may remain in the bore to serve as a conduit for carrying production fluids to surface. This is often termed a"dual concentric completion"or a "velocity string". Alternatively, the inner support is retrieved while the outer support remains in the bore.

Preferably, the inner and outer supports are coaxial.

Where necessary, appropriate spacers may be provided between the supports.

Preferably, a fluid, typically a drilling fluid or"mud", is pumped into the bore during the drilling step.

The fluid may be passed through a selected one or more of the channels defined by a tubular inner support, an inner annulus between the inner support and the outer support, or an outer annulus between

the outer support and the bore wall, and returned to surface via one or more of the other channels. The fluid may be utilised to drive a downhole motor, which may be a positive displacement motor and may be utilised to drive the drill bit, and may serve as a medium for transmission of pressure pulse signals from a measurement-while-drilling(MWD) apparatus, which will typically be provided as part of a bottom hole assembly (BHA), to surface. Gas or another low density fluid may also be pumped into the bore during the drilling step, either mixed into the fluid or separately through one of the channels for mixing with the drilling fluid at or adjacent the drill bit and reducing the hydrostatic head resulting from the column of fluid above the bit, andfacilitating"underbalance"drilling. The presence of gas in one or more of the channels may also be used to increase the effective buoyancy of the supports, and even provide a degree of positive buoyancy, and facilitate the drilling of longer reach bores. The channels may be selectively closed or sealed as desired, selected individually at will, and the direction of fluid circulation may be varied or reversed, as drilling conditions require.

Preferably, the drill bit is mounted to the inner support, or a BHA on the inner support. The inner support may itself be coupled to the outer support, facilitating the transmission of forces from surface, for example the application of weight on bit (WOB), and providing resistance to torsion, tension and other forces, by the larger diameter outer support. At least a portion of the inner support may thus be relatively light and flexible, and need not be capable of withstanding any significant torsion, tension or compression. Preferably, the coupling between the inner and outer supports is remotely disengageable, to facilitate retrieval of the inner support. The coupling may be disengaged by any appropriate means, including electrically, mechanically or hydraulically actuated means, or means actuated by a combination of inputs.

Preferably, the drill bit is collapsable, such that the bit may be retrieved through the outer support.

Alternatively, the bit may be expendable or sacrificial, that is the drill bit and also possibly other BHA components and sections of the inner member, may be disengageable and remain at the end of the bore.

Preferably, the drill bit is expandable, such that, for example, the bit may be run into a cased bore and then expanded below the casing to a larger diameter than the inner diameter of the casing, and of course to a larger diameter than the outer member.

Preferably, a bottom hole assembly (BHA) is located at least partially within the outer member, and is preferably mounted to the inner member. Thus, the BHA is protected by the presence of the outer member during the drilling operation. The BHA is preferably coupled to the outer member, which coupling may be via the inner member, such that stresses experienced or created by the BHA are transferred to the outer member.

A downhole tractor may be provided to apply weight to the bit or to pull the members through the bore. The tractor may be powered by any appropriate means. The tractor may be expandable or retractable.

The members may be of any appropriate material, including metals such as steel or other alloys, composites, or any combination thereof.

One or both of the members may comprise signal conductors, for example embedded conductors for power or signal transmission, or fibre optic cables. One or both members may contain one or more signal conductors.

The outer member may comprise a pressure containment layer. The outer member may comprise an inner low friction liner or coating, to facilitate withdrawal of the inner member.

The outer member may be expandable, and the method may include the further step of expanding the outer member to a larger diameter.

The outer member may extend the length of the inner member, or may extend over only a distal or intermediate portion of the inner member; if a section of bore is being drilled beyond a length of cased bore, the outer member may be of a length corresponding to the length of the bore section to be drilled.

One or both of the outer member and the inner member may form part of a velocity string.

If desired, additional tubular members or supports may be provided, and alternatively or in addition, additional tubular members providing little or no support may be provided.

A packer or other sealing arrangement may be provided between the inner and outer members. Alternatively, or in addition, a packer or other sealing arrangement may be provided between the outer member and bore wall. In a further alternative, a packer or other sealing arrangement may be provided inside the inner member to seal an inner diameter of the inner member. The packer or other sealing arrangement may be pumped down inside the inner member.

This may be used to provide pressure containment of the inner member. This may be particularly advantageous where the bit and\or other BHA components are disengaged from the inner member, as this may allow sealing prior to disengagement.

These and other aspects of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:
Figure 1 is a schematic, part-sectional view of apparatus in accordance with a preferred embodiment of the present invention;
Figure 2 is a schematic part cut away perspective view of a portion of the apparatus of Figure 1 ;
Figure 3 is a sectional view on line 3-3 of Figure 2 ;
Figure 4 is a side view of a portion of the apparatus of Figure 1; showing elements of the apparatus in the process of disengaging;
Figure 5 is a sectional view on line 5-5 of Figure 4;
Figure 6 is a part-sectional view of the apparatus of
Figure 1, shown in the process of retraction of an inner support of the apparatus ;
Figure 7 is a schematic sectional view of apparatus in accordance with another embodiment of the invention ; being utilised in an underbalance drilling operation;
Figures 8a-8h of the drawings are schematic illustrations of part of an apparatus in accordance with an embodiment of the present invention, and illustrating various possible circulation configurations ; and
Figures 9 and 10 are schematic part-sectional views of apparatus in accordance with additional embodiments of the present invention.

Reference is first made to Figure 1 of the drawings, which illustrates apparatus 20 in accordance with a preferred embodiment of the present invention, and in particular the distal end of the apparatus being illustrated in the course of a drilling operation.

The apparatus 20 is shown located in the end of the drilled bore 22 and comprises outer tubing 24 and inner tubing 26, with an expandable drill bit 28 being mounted on the inner tubing 26.

In this embodiment, both the inner and outer tubing26, 24 extend to surface. The inner tubing 26 provides mounting for various drilling apparatus, including a measurement-while-drilling (MWD) device 30 which transmits information to surface via pressure pulses in the drilling fluid passing through the inner tubing 26. An expandable tractor 32 is mounted on the inner tubing 26 and extends beyond the end of the outer tubing 24, the tractor 32, being drilling fluid driven to advance the apparatus 20 through the bore 22. A positive displacement motor (PDM) 34 is mounted below the tractor 32, and is drilling fluidfluid driven to rotate the bit 28.

During drilling, the ends of the inner and outer tubing 26,24 are coupled together by a latch sub 36, mounted on the inner tubing 26 between the MWD 30 and the tractor 32, which has radially extendable keys or dogs 38 for engaging a profile 40 provided on an outer tubing end joint 42. This allows linear forces, such as tension forces, and torque to be transmitted between the larger diameter and generally more compression and torsion resistant outer tubing 24 and the inner tubing 26.

Reference is now also made to Figures 2 and 3 of the drawings, which illustrate further details of the inner and outer tubing 26,24. In particular, it may be seen that the walls of both the inner and outer tubing include embedded signal transmission members 44 in the form of fibre optic and electric cables for power transmission from surface to elements of the bottom hole assembly (BHA) and for data transmission from the BHA to surface. As illustrated, the inner tubing 26 may also accommodate a larger diameter cable or umbilical 46.

Reference is now made to Figures 4,5 and 6 of the drawings, which illustrate steps in the retrieval of the inner tubing 26.

When a drilling operation has been completed, or it is desired to retrieve the inner tubing26 and BHA for

some other reasons, the latch dogs 38 are retracted, as are the tractor 32 and bit 28. The BHA may then be retrieved through the outer tubing 24 and pulled to surface, while the outer tubing 24 remains in the bore 22. Alternatively, the BHA may be ejected from the end of the inner tubing 24.

Reference is now made to Figure 7 of the drawings, which illustrates apparatus 50 of another embodiment of the invention being utilised in an underbalance drilling operation. In practice, the apparatus 50 will include many of the features of the apparatus20 described above, however these have been omitted from the figure in the interest of clarity.

Drilling fluid is being supplied to the drill bit 52 via the bore 53 of the inner tubing 54, which fluid powers theMWD and PDM (not shown) and facilitates data transfer from the PDM to surface. The inner annulus 56 between the inner tubing 54 and the outer tubing 58 is utilised to transport nitrogen gas from surface.

The drilling fluid, drill cuttings and gas mix in the bottom end of the drill, bore 60, and travel to the surface via the outer annulus 62 between the outer tubing 58 and the wall of the drilled bore 60.

The presence of the gas in the inner annulus 56 increases the buoyancy of the tubing string, which may be useful, particularly in extended reach wells.

The tubing arrangement of the embodiments of the invention provides a high degree of flexibility in circulation, as illustrated in Figures 8a-8h of the drawings. The figures illustrate that one or more of the inner tubing 70, inner annulus 72, and outer annulus 74 may be utilised to deliver fluid from surface, or return or deliver fluid to surface. As illustrated in Figures 8c, 8d, 8g and 8h, one of the inner or outer annuli may be sealed to prevent fluid passage there-through.

Figure 9 shows apparatus 80 in accordance with a still further embodiment of the invention. In this example, the outer tubing 82 extends only over a relatively short section of the inner tubing 84. This arrangement may be useful to, for example, accelerate return fluid in the outer annulus 86 as it passes around the tubing 82, or the tubing 82 may serve as a'patch'. Alternatively, the arrangement can be used to transport a length of outer tubing such as the outer tubing 82, corresponding to the length of an open hole to be drilled. This may be of particular use in, for example, drilling of a lateral borehole ; it will be understood that packers (not shown) may be provided for selective sealing of the outer annulus 86, either between the outer or inner tubing 82,84 and the bore.

Figure10 illustrates a further alternative embodiment, in which the tubing of the apparatus 90 serves as a double pressure barrier, the inner tubing 92 serving as a first barrier and the outer tubing 94 serving as a second barrier. A seal 96 between the inner and outer tubing 92,94 may be arranged to permit circulation in one direction or to prevent flow on altogether, thus forming a dual pressure barrier at surface and along the length of the bore. Also packers 98 may be provided for sealing external annulus at one or both of the lower end of the apparatus 90 and at surface, and an additional packer 102 may be provided to act as a dual inner annulus barrier.

It will be apparent to those of skill in the art that the above described embodiments are merely examples of the invention and that various modifications and improvements may be made thereto, without departing from the scope of the invention.

DRILLING METHOD

Claims of **WO0210549**

CLAIMS1. A method of drilling and lining a bore in an earth formation, the method comprising the steps: providing a tubular outer elongate member and an inner elongate member located within the outer member, at least one of the members being spoolable; mounting a drill bit to one of the members; and drilling a bore by advancing the drill bit through the earth formation and advancing the members through the bore..

2. The method of claim1, further comprising providing both members in the form of spoolable members.

3. The method of claim 1 or 2, further comprising transmitting force to or from the bit via at least one of the inner and outer members.

4. The method of claim 1,2 or 3, further comprising running in and retrieving the at least one of the members using an injector head and lubricator.

5. The method of claim 4, further comprising conveying the at least one member into the bore while the bore is in production.

6. The method of claim 1, further comprising forming one of the members of pipe sections.

7. The method of any of the preceding claims, further comprising expanding the outer member.

8. The method of any of the preceding claims, further comprising retrieving the inner support while the outer support remains in the bore.

9. The method of any of the preceding claims, further comprising pumping drilling fluid into the bore during drilling.

10. The method of claim 9, wherein the fluid is passed through a channel defined by a tubular inner support.

11. The method of claim 9 or 10, wherein the fluid is passed through a channel defined by an inner annulus between the inner support and the outer support.

12. The method of claim 9,10 or 11, wherein the fluid is passed through a channel defined by an outer annulus between the outer support and the bore wall.

13. The method of claim 10,11 or 12, wherein the fluid is returned to surface via one or more of the other channels.

14. The method of any of claims 9 to 13, wherein the fluid is utilised to drive at least one of a downhole motor, tractor or other BHA component.

15. The method of any of claims 9 to 14, wherein the fluid serves as a medium for transmission of pressure pulse signals from a measurement-while-drilling(MWD) apparatus to surface.

16. The method of any of claims 9 to 15, wherein gas is pumped into the bore during the drilling step.

17. The method of claim 16, wherein the gas is mixed with the fluid at surface.

18. The method of claim 16, wherein the gas is pumped into the bore separately of the fluid and mixed with the drilling fluid at or adjacent the drill bit.

19. The method of claim 16,17 or 18, wherein the presence of gas is utilised to increase the effective buoyancy of the supports.

20. The method of any of the preceding claims, further comprising utilising at least one of the members to carry production fluids to surface.

21. The method of any of the preceding claims, further comprising closing a channel at least partially defined by one or more of the members.

22. The method of any of the preceding claims, further comprising circulating fluid in a first direction through channels at least partially defined by one or more of the members and then changing the direction of fluid circulation.

23. The method of any of the preceding claims, further comprising coupling the inner member to the outer member.

24. The method of claim 23, further comprising disengaging the coupling and retrieving the inner member.

25. The method of any of the preceding claims, further comprising collapsing the drill bit and retrieving the bit through the outer member.

26. The method of any of claims 1 to 24, further comprising: mounting the bit on the inner member; disengaging the bit from said member; and retrieving at least a portion of the inner member.

27. The method of any of the preceding claims, further comprising expanding the drill bit.

28. The method of claim 27, further comprising running the bit into a cased bore and then expanding the bit below the casing to a larger diameter than the inner diameter of the casing.

29. The method of any of the preceding claims, further comprising locating a bottom hole assembly (BHA) at least partially within the outer member.

30. The method of claim 29, further comprising mounting the BHA to the inner member.

31. The method of claim 29 or 30, further comprising coupling the BHA to the outer member such that stresses experienced or created by the BHA are transferred to the outer member.

32. The method of any of the preceding claims, further comprising providing a downhole tractor and utilising the tractor to apply weight to the bit or to pull the members through the bore.

33. The method of any of the preceding claims, further comprising expanding the outer member to a larger diameter.

34. The method of any of the preceding claims, further comprising providing a sealing arrangement between the inner and outer members.

35. The method of any of the preceding claims, further comprising providing a sealing arrangement between the outer member and bore wall.

36. The method of any of the preceding claims, further comprising providing a sealing arrangement inside the inner member.

37. The method of claim 36, further comprising pumping the sealing arrangement down inside the inner member.

38. Apparatus for drilling and lining a bore in an earth formation, the apparatus comprising: a tubular outer elongate member and an inner elongate member located within and coupled the outer member, at least one of the members being spoolable; and a drill bit mounted to one of the members.

39. The apparatus of claim 38, wherein at least one of the inner and outer members is a support member capable of transmitting force.

40. The apparatus of claim 38 or 39, wherein both of the members are spoolable.

41. The apparatus of claim 38 or 39, wherein at least one of the members is sectional.

42. The apparatus of claim 41, wherein at least one of the members is formed of jointed pipe.

43. The apparatus of any of claims 38 to 42, wherein the outer member is expandable to a larger diameter.

44. The apparatus of any of claims 38 to 42, wherein at least one of the members is of a composite material.

45. The apparatus of any of claims 38 to 44, wherein the inner elongate member is tubular.

46. The apparatus of any of claims 38 to 45, wherein the inner and outer members are coaxial.

47. The apparatus of claim 46, wherein spacers are provided between the supports.

48. The apparatus of any of claims 38 to 47, further comprising a downhole motor.

49. The apparatus of claim 48, wherein the motor is a positive displacement motor.

50. The apparatus of any of claims 38 to49, further comprising a measurement-while-drilling(MWD) apparatus.

51. The apparatus of any of claims 38 to 50, wherein the drill bit is mounted to the inner member.

52. The apparatus of any of claims 38 to 51, wherein the coupling between the inner and outer supports is remotely disengageable.

53. The apparatus of any of claims 38 to 52, wherein the drill bit is collapsable and retrievable through the outer member.

54. The apparatus of any of claims 38 to 52, wherein'the drill bit is remotely disengageable from said one of the members.

55. The apparatus of any of claims 38 to 54, wherein the drill bit is expandable.

56. The apparatus of any of claims 38 to 55, wherein a bottom hole assembly (BHA) is located at least partially within the outer member.

57. The apparatus of claim 56, wherein the BHA is mounted to the inner member.

58. The apparatus of claim 56 or 57, wherein the BHA is coupled to the outer member.

59. The apparatus of any of claims 38 to 58, further comprising a downhole tractor.

60. The apparatus of claim 59, wherein the tractor is retractable.

61. The apparatus of any of claims 38 to 60, wherein at least one of the members comprises signal conductors.

62. The apparatus of any of claims 38 to 61, wherein the outer member comprises a pressure containment layer.

63. The apparatus of any of claims 38 to 62, wherein the outer member comprises an inner low friction liner or coating, to facilitate withdrawal of the inner member.

64. The apparatus of any of claims 38 to 63, wherein the outer member extends over the length of the inner member.

65. The apparatus of any of claims 38 to 63, wherein the outer member extends over only a distal portion

of the inner member.

66. The apparatus of any of claims 38 to 63, wherein the outer member extends over only an intermediate portion of the inner member.

67. The apparatus of any of claims 38 to 66, wherein at least one of the members forms part of a velocity string.

68. The apparatus of any of claims 38 to67, wherein a sealing arrangement is provided between the inner and outer members.

69. The apparatus of any of claims 38 to 68, wherein a sealing arrangement is provided for location between the outer member and a bore wall.

70. The apparatus of any of claims 38 to 69, wherein a sealing arrangement is provided inside the inner member to seal an inner diameter of the inner member.

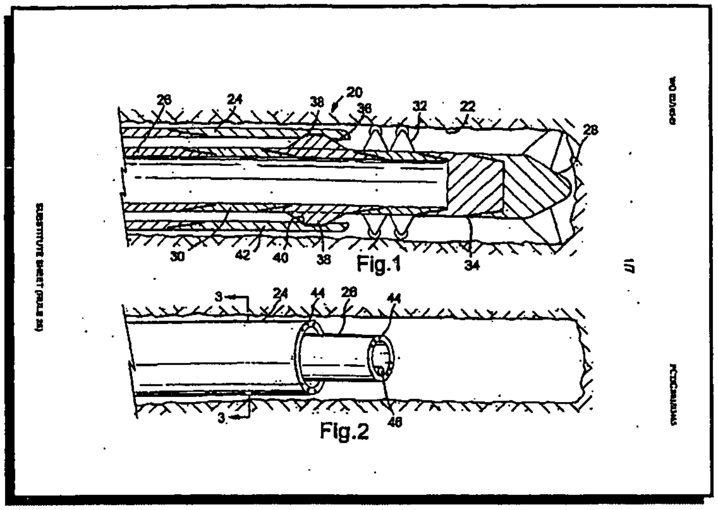

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Fig.1
Fig.2

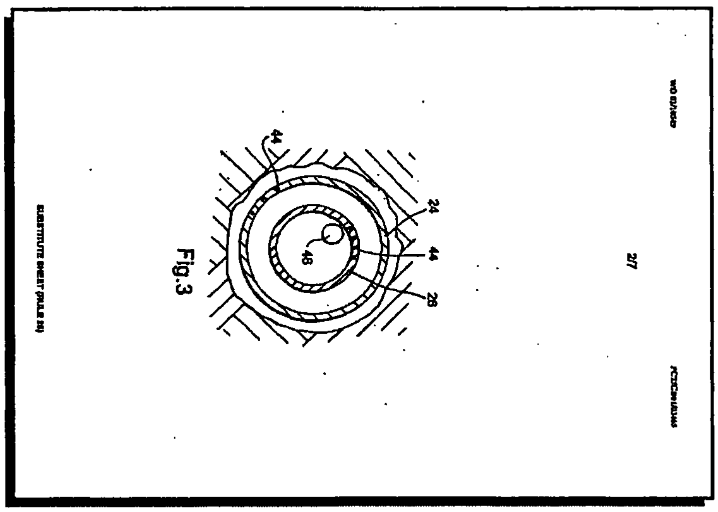
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Fig.3

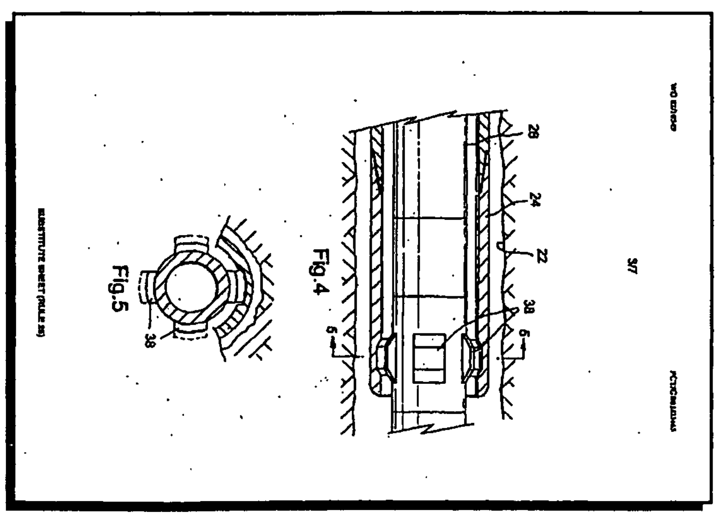
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Fig.4
Fig.5

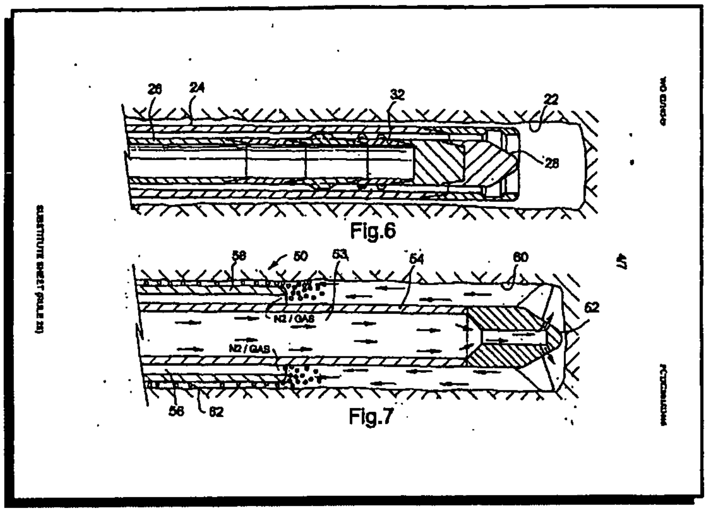
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Fig.6
Fig.7
N2 / GAS
N2 / GAS

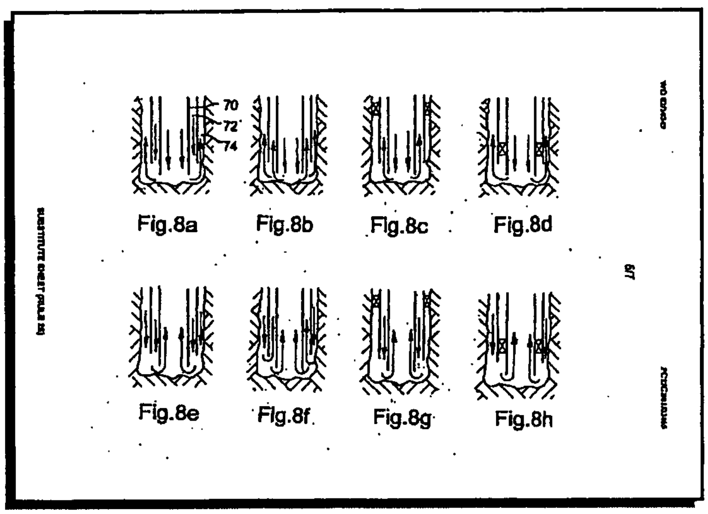
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Fig.8a
Fig.8b
Fig.8c
Fig.8d
Fig.8e
Fig.8f
Fig.8g
Fig.8h

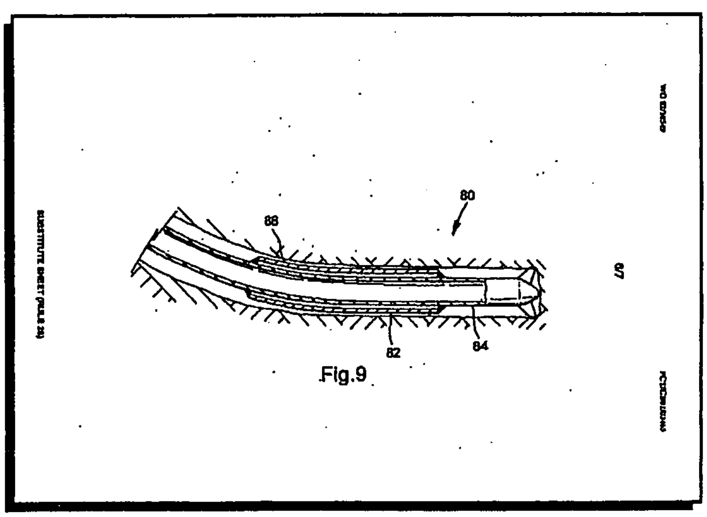
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Fig.9